JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

H 103

VOLUME V, 1915

BOARD OF EDITORS

FRED. E. WRIGHT
GEOPHYSICAL LABORATORY

WILLIAM R. MAXON
NATIONAL MUSEUM

EDSON S. BASTIN
GEOLOGICAL SURVEY

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
THE WAVERLY PRESS
BALTIMORE, MD.

DARTMOUTH COLLEGE LIBRARY

506
q W277j
v.5

OCT 10 1931
307148
gen

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. V JANUARY 4, 1915 No. 1

PHYSICS.—*The total emissivity of platinum and the relation between total emissivity and resistivity.* PAUL D. FOOTE. Communicated by C. W. WAIDNER.

On the basis of the Maxwell theory, Planck[1] has derived the following equation representing the relation between the reflection coefficient of a metallic surface, the volume resistivity of the metal, and the wave length of the incident radiation:

$$R_\lambda = \frac{\sqrt{3600\,\lambda^2/r^2 + 1} + 1 - \sqrt{2(\sqrt{3600\,\lambda^2/r^2 + 1} - 1)}}{\sqrt{3600\,\lambda^2/r^2 + 1} + 1 + \sqrt{2(\sqrt{3600\,\lambda^2/r^2 + 1} - 1)}} \quad . . (1)$$

where R_λ is the ratio of the intensities of the reflected to the incident radiation, r the volume resistivity of the metal in ohms cm, and λ the wave length of the radiation in cm. Defining the monochromatic emissivity as $E_\lambda = 1 - R_\lambda$ and expanding the above expression into a series of ascending powers of $\sqrt{r/\lambda}$, Hagen and Rubens[2] have obtained the following equation in which the terms of higher order than those indicated are negligible:

$$E_\lambda = 0.365\sqrt{\frac{r}{\lambda}} - 0.0667\left(\frac{r}{\lambda}\right) + \quad . . . . . (2)$$

The spectral distribution of the energy radiated by a black body may be expressed by the Planck equation:

[1] Planck, Sitz. Königl. Ak. Wiss. Berlin, p. 278. 1903.
[2] Hagen and Rubens, Königl. Ak. Wiss. Berlin, p. 468. 1910.

$$J_\lambda = C_1 \lambda^{-5} \left[e^{\frac{c_2}{\lambda T}} - 1 \right]^{-1} \quad \ldots\ldots\ldots\ldots (3)$$

where T is the absolute temperature and $c_2 = 1.4450$ cm. deg. The total energy (any arbitrary unit) radiated by a black body is given by the integral of equation (3):

$$J = \int^{\infty} J_\lambda \, d\lambda \quad \ldots\ldots\ldots\ldots (4)$$

The total energy radiated by a nonblack metal may be expressed as the integral of the Planck relation multiplied by the monochromatic emissivity:

$$J' = \int_0^{\infty} J_\lambda E_\lambda \, d\lambda \quad \ldots\ldots\ldots\ldots (5)$$

If the total emissivity E of a metal is defined as the ratio of the energy emitted by the metal at an absolute temperature T to that emitted by a black body at the same temperature, one obtains the following relation:

$$E = \frac{J'}{J} = \frac{\int_0^{\infty} J_\lambda E_\lambda d\lambda}{\int_0^{\infty} J_\lambda d\lambda} \quad \ldots\ldots\ldots\ldots (6)$$

Equation (6) may be converted to the gamma function form and is hence readily integrable. One thus obtains the following expression for the total emissivity of a metal:

$$E = 0.5736 \sqrt{rT} - 0.1769 \, rT \quad \ldots\ldots\ldots\ldots (7)$$

where T is the absolute temperature of the radiating metal and r the volume resistivity in ohms cm at this temperature.

It is therefore apparent that the total emissivity of most pure metals should increase with increasing temperature both because of the increasing value of T in equation (7) and because of, in general, the increasing volume resistivity. The increase in total emissivity with increasing temperature has been observed in nearly all of the extremely few instances where this quantity has been measured.[3]

[3] Langmuir, Trans. Am. Elec. Chem. Soc., **23**: 321. 1913; Randolph and Overholser, Phys. R., **2** (2): 144. 1913; Burgess and Foote, Bureau of Standards Scientific Paper **224**.

The above derivation is essentially that of Aschkinass,[4] who, in an extensive paper, has discussed the energy emission of metals, the value of λT_m of the displacement law for metals, and the relation of various properties of the radiation from metals to similar properties of black body radiation. He used for the value of E_λ the first term only of equation (2), the one term formula having been derived by Planck;[1] but inasmuch as Hagen and Rubens[2] have since found that the one term relation was insufficient, it appeared of interest to derive the somewhat general relation (7) for total emissivity from the more accurate relation (2) for monochromatic emissivity. The first term of equation (7) may be obtained directly from Aschkinass' work by dividing his equation (10) by the integral of Planck's spectral equation and correcting the value of c_2 in (10) to the present accepted value of 1.445. The second term of equation (7) becomes equal to 11 per cent of the first term at 1700°C. and hence is of considerable importance, especially at the higher temperatures.

In order to check formula (7) quantitatively, measurements have been made, with Mr. Kellberg's assistance, upon the total emissivity of platinum. The apparent temperatures of thin platinum strips were measured by three radiation pyrometers of the Féry mirror type and the apparent temperatures for a wave length $\lambda = 0.65\mu$ were obtained with a Holborn Kurlbaum optical pyrometer. The apparent temperatures measured by the optical pyrometer were converted in the usual manner to true temperatures using the value of $E_{0.65} = 0.33$. The emissivity of this metal for $\lambda = 0.65\mu$ is independent of the temperature.[5] This is of course in contradiction to the Maxwell relation (2) above. But it must be noted that, for metals, the visible spectrum is usually the region where resonance phenomena are taking place, and hence one would here expect that the general theoretical deductions might fail to apply, as is experimentally found to be the case. This fact does not materially

[4] Aschkinass, Ann. d. Physik., (4) **17**: 960. 1905.

[5] Waidner and Burgess, Bureau of Standards Scientific Paper **55**; Mendenhall, Astrophys. J., **33**: 91. 1911; Spence, Astrophys. J., **37**: 194. 1913.

alter the validity of the expression (7) for the total emissivity, since by far the greater part of the radiant energy of glowing metals at temperature below 1500°C. is confined to a spectral region where resonance phenomena do not exist.

The relation between the true absolute temperature T of a material, the apparent absolute temperature, S, measured by a total radiation pyrometer, and the total emissivity is given by the following expression:

$$E = \frac{S^4 - T_0^4}{T^4 - T_0^4} \quad \ldots\ldots\ldots\ldots (8)$$

where T_0 is the temperature of the receiver. The temperature coefficient of mass resistivity of pure platinum from 0 to 1100°C. is very accurately given by the Callendar[6] parabolic equation where $\delta = 1.49$ and C the fundamental coefficient is 0.0039.

It does not appear likely that serious error is introduced by the extrapolation of this equation to the melting point of platinum. Observations by Pirani,[7] Holborn and Wien,[8] and Langmuir[9] above 1100°C. do not deviate seriously from the parabolic relation. Langmuir concluded from his determinations that the relation was linear above 1200° but he uses the value 1710° instead of 1755° for the melting point of platinum. If his data are corrected for the error in the temperature scale the observations follow the Callendar formula quite satisfactorily. The mass resistivity of a 0.6 mm. × 100 cm. wire of Heraeus platinum, presumably of the same degree of purity as that of the strips used in the emissivity determinations, was very kindly measured by Mr. C. F. Hanson of this Bureau, with an accuracy of about 0.1 per cent. Reduction to the volume resistivity at 0°C. gave the value of 9.77×10^{-6} ohms cm, with possibly an error as great as 1 per cent. The ratio r_t/r_o, determined by resistances at constant mass, is equal to the ratio determined at constant volume within the accuracy of the present work.

[6] Waidner and Burgess, Bureau of Standards Scientific Paper **124**: 151.
[7] Pirani. Verh. d. Phys. Ges., **12**: 315. 1910.
[8] Holborn and Wien, Ann. d. Physik, **59**: 360. 1896.
[9] Langmuir, J. Am. Chem. Soc., **28**: 1357. 1906.

Figure 1 represents the total emissivity of platinum as a function of the temperature in the range 0° to 1700°C.

The computed points are represented by crosses. Preliminary observations made with radiation pyrometers which were later found to be somewhat defective are shown by small dots and the final observations made with an instrument comparatively free from these defects are plotted as circles. The large dot at 15°C. was obtained from the work of Hagen and Rubens on the reflection coefficients of platinum. These investigators have determined the dispersion of the reflection coefficient to

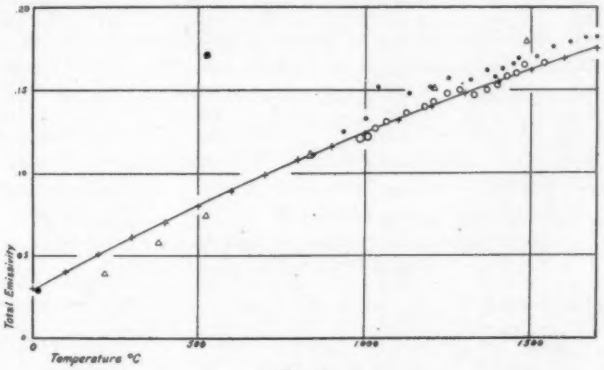

Fig. 1

25μ. If the values of $E_\lambda = 1 - R_\lambda$ are substituted in equation (6) the total emissivity may be btained. The integration was performed graphically. The triangles represent the observations of Lummer and Kurlbaum.[10]

The agreement between the theoretical and experimental values is excellent, when one considers the difficulties involved in an accurate determination of total emissivity. The deviations of the computed values from the observed values are in general much less than $\pm$ 0.01, which is about the limit of accuracy of the experimental determinations.

Table I presents a summary of the values of the total emissivity of pure platinum for the temperature range 0° to 1700°C.

[10] Lummer and Kurlbaum, Verh. d. Phys. Ges., **17**: 106. 1898.

Table II shows the corrections which must be applied to the temperature observed with a radiation pyrometer, when sighted upon pure platinum, in order to obtain the true temperature of the radiating platinum. The temperature of the receiver is considered as 300° abs.

TABLE I

TOTAL EMISSIVITY VS. TEMPERATURE

DEGREES CENTIGRADE	EMISSIVITY	DEGREES CENTIGRADE	EMISSIVITY
0	0.030	900	0.116
100	0.040	1000	0.124
200	0.051	1100	0.132
300	0.061	1200	0.140
400	0.070	1300	0.148
500	0.080	1400	0.155
600	0.089	1500	0.162
700	0.099	1600	0.169
800	0.108	1700	0.175

TABLE II

TOTAL RADIATION PYROMETER SIGHTED ON PLATINUM
(RECEIVER = 300° ABS.)

OBSERVED TEMPERATURE	CORRECTION TO ADD	TRUE TEMPERATURE
200° C.	365° C.	565° C.
300	425	725
400	475	875
500	520	1020
600	560	1160
700	595	1295
800	630	1430
900	660	1560
1000	695	1695

In a subsequent paper the emissivity of other metals will be discussed. Approximate measurements have already indicated that equation (7) is a general relation, and is by no means restricted to the example cited in the present paper.

SUMMARY

A definite relation has been found to exist between the total emissivity and the volume resistivity of a metal. This relation

follows directly from the Maxwell theory of reflection and absorption. Experimental determinations of the total emissivity of platinum have verified the derived relation.

MINERALOGY.—*Four new minerals.* WALDEMAR T. SCHALLER, Geological Survey.

The following very brief notes of four new minerals are given in order to secure priority, as it is desired to extend further the optical determinations before the detailed papers are published. The formulas given have all been derived from the completed chemical analyses.

Minasragrite is a blue hydrous vanadium sulphate from Minasragra, Peru. The monoclinic crystals dissolve readily in cold water. The vanadium is quadrivalent and the mineral is a hydrous acid vanadyl sulphate with the formula $V_2O_4 \cdot 3SO_3 \cdot 16H_2O$, which is interpreted as $(V_2O_2)H_2(SO_4)_3 \cdot 15H_2O$.

Fernandinite is a green hydrous calcium vanadyl vanadate from Minasragra, Peru. The analysis yields the formula $CaO \cdot V_2O_4 \cdot 5V_2O_5 \cdot 14H_2O$, which may be written, as a metavanadate as follows: $[H_4Ca(V_2O_2)][VO_3]_{10} \cdot 12H_2O$.

Shattuckite is a blue hydrous copper silicate from the Shattuck Arizona Copper Company's mine at Bisbee, Arizona. Its formula is $2CuO \cdot 2SiO_2 \cdot H_2O$ and it is close to plancheite in composition but differs considerably therefrom in its optical properties. Shattuckite forms pseudomorphs after malachite and also occurs as small spherulites.

Bisbeeite is found with the shattuckite and forms pseudomorphs after the shattuckite pseudomorphs of malachite. In composition bisbeeite is identical with dioptase, $CuO \cdot SiO_2 \cdot H_2O$, but is orthorhombic, pale blue to nearly white in color, and has distinct optical properties.

ZOOLOGY.—*The geographical divisions of the recent crinoid fauna.* AUSTIN H. CLARK, National Museum.

The division of the present crinoid fauna as a whole into satisfactory zoögeographic regions has proved to be a task of no little difficulty, chiefly because of the almost complete absence

of these animals from littoral waters having a seasonal fluctuation of temperature and salinity, and because of the complete intergraduation of the littoral and the abyssal types.

Yet the very features which place the greatest obstacles in the way of outlining the zoögeographic divisions indicated by the crinoids at the same time suggest that these divisions are of more than usual significance, and are more fundamental in character, especially in their relation to the zoögeographic divisions of the past, than those of the other groups of marine organisms.

In the construction of the scheme outlined below, instead of following the usual method of subordinating the biological to the geographical aspect of the problem, I have examined all the known species of recent crinoids from the point of view of their systematic affinities and their obvious relationships, later assigning them to the various zoögeographic divisions in which they appear naturally to group themselves, so that these divisions are outlined purely from the biological viewpoint, and follow, if it may be so expressed, the phylogenetic rather than the geographical migrations of the class.

The crinoid fauna of the present seas is found to be divisible into two main sections, which, though faunally equivalent, are different in size and range. These two zoögeographic units are:

I. The Australian Fauna: Occurring all around the coasts of Australia, and including the Aru Islands and southern New Guinea (Papua).

The Australian fauna, which is littoral and sublittoral only, is characterized by certain very distinctive, primitive and aberrant specific types. Three genera, *Comatulella*, *Oligometrides* and *Ptilometra* are confined to it, while *Zygometra* and *Petasometra* are here very highly developed. It is related to the Indo-Pacific-Atlantic fauna, though it cannot be considered as a part of it, or as a derivative from it. Of the several divisions of the Indo-Pacific-Atlantic fauna it is most closely allied with the Caribbean, and two of the three peculiar genera are, outside of the Australian region, most closely related to Caribbean types, *Comatulella* to the genus *Comactinia*, and *Oligometrides* to the genus *Analcidometra;* it is interesting to note that neither *Comactinia* nor *Analcidometra* occur on the eastern shores of the Atlan-

tic. The Australian and the Indo-Pacific-Atlantic faunas overlap more or less in the Moluccas and in the Lesser Sunda Islands, and at the present time the entity of the former has become clouded and largely masked through the intrusion of numerous alien types from the Malayan region, particularly on the east Australian coast. The Australian fauna appears to be the last remnant of a once dominant fauna which, overwhelmed by a more vigorous fauna of subsequent origin, now persists only in the Australian littoral, and, almost entirely submerged, in the littoral and sublittoral zones of the Caribbean Sea.

II. The Indo-Pacific-Atlantic Fauna: Primarily characteristic of the region from Formosa to the Korean Straits, and eastward to Tokyo Bay, the Hawaiian Islands, the Kermadec Islands, the Admiralty Islands, the Meangis Islands, the Moluccas, the Lesser Sunda Islands, thence westward and northward along the southern shores of Java and Sumatra to the Nicobar and Andaman Islands, Ceylon and southwestward to Madagascar and southeastern Africa, northwestern Africa and southwestern Europe, and the Caribbean Sea. From this primary region, which falls into numerous subdivisions, faunal units, more or less differentiated from the original unit, have been and are being evolved (the "derived" faunas mentioned beyond) which occupy the entire area of the present seas at all depths, excepting only the Australian littoral.

The Indo-Pacific-Atlantic fauna, chiefly developed between the temperature of 10° and 18°.33C. (50° and 65° Fahrenheit), and composed entirely of species of moderate size, none very large and none very small, appears to represent the dominant, conservative, and homogeneous widely spread fauna of the more recent geological past, and to be the original homogeneous unit from which the recent faunal units are being evolved (1) by disruption of the ancient land continuity and consequent geographical differentiation, (2) by migration of certain virile types into the cold abysses where, becoming modified, they undergo redistribution as abyssal types, and (3) by migration of other virile types into the purely recent hot tropical littoral where, becoming modified, they are redistributed as a tropical littoral fauna.

The geographical divisions of the Indo-Pacific-Atlantic fauna are the following:

1. *Southern Japanese-Hawaiian:* Formosa to the Korean Straits, and eastward to Tokyo Bay; the Hawaiian Islands.

a. Southern Japanese: Formosa to southern Japan, from the Korean Straits to Tokyo Bay. *b*. Hawaiian: Hawaiian Islands.

2. *Kermadec Island:* Kermadec Islands.

3. *East Indian-Australian:* Andaman Islands southward and eastward to the Lesser Sunda Islands, the Moluccas, Celebes and the Meangis Islands, and southward (in deeper water than that in which the Australian fauna occurs) to southwestern Australia and Tasmania.

4. *Ceylon-East African:* Ceylon westward and southwestward to Madagascar and southeastern Africa.

5. *Atlantic:* Northwestern Africa and southwestern Europe, and the Caribbean Sea.

a. East Atlantic: Northwestern Africa and southwestern Europe. *b*. Caribbean: Caribbean Sea.

The derived faunas originating from the Indo-Pacific-Atlantic which include chiefly or entirely littoral and shallow water types are the following:

1. *Malayan:* The region westward and northward of the Andaman, Nicobar and Lesser Sunda Islands, and east of the Moluccas and Celebes, as far as the Philippine Islands and Hong Kong.

2. *Littoral Atlantic:* Norway to the Gulf of Guinea, including the Mediterranean Sea; Caribbean Sea to Rio de Janeiro, Brazil.

a. Afro-European: Norway to the Gulf of Guinea, including the Mediterranean Sea.

b. American: Caribbean Sea to Rio de Janeiro, Brazil.

3. *Red Sea*: Red Sea, and eastward to the Persian Gulf.

The derived faunas originating from the Indo-Pacific-Atlantic which include exclusively primarily deep water types are the following:

1. *Arctic:* Arctic Ocean and north Atlantic, south to Nova Scotia and the extreme north of Europe; the western shores of the Seas of Okhotsk and Japan.

a. Arctic Ocean: Arctic Ocean, and the extreme north Atlantic.

b. East Asiatic: Western shores of the Seas of Okhotsk and Japan.

2. *Antarctic:* Antarctic regions, and the west coast of South and North America to Alaska, westward to the western Aleutian Islands, and southward to southern Japan.

a. Continental Antarctic: Coasts of the Antarctic continent, Kerguelen, and Heard Island.

b. Megellanic: Cape Horn northward to Alaska, westward to the western Aleutian Islands, thence southward to Tokyo and Sagami Bays, Japan.

c. Abyssal: The abysses in the extreme south, and in the eastern and northern portions of the Pacific and Atlantic Oceans; probably also the abysses in the eastern part of the Indian Ocean.

The various geographical divisions of the Indo-Pacific-Atlantic fauna occupy each a relatively circumscribed area, supporting distinctive species; but the derived faunas, while characteristic of the area as delimited above, have ill-defined borders and encroach more or less upon the surrounding faunas.

Thus the Malayan fauna, especially characteristic of, and apparently originating in, the very warm water of the Malayan littoral, is very widely spread wherever very warm water occurs; a few of its distinctive species reach southwestern Japan, one reaches the Hawaiian Islands, and several reach Australia, where they overlie the species of the Australian fauna proper, especially on the northeastern and eastern coasts, reaching as far south as Perth and Sydney; Ceylon also supports a few representatives of this fauna. The Littoral Atlantic fauna, excepting in the Mediterranean Sea, overlies the true Atlantic fauna. The other derived faunas similarly have extended their ranges more or less into territory occupied originally by other faunal units.

The derived faunas appear to be the dominant faunas of the present seas, composed of the most vigourous and most adaptable elements in the original Indo-Pacific-Atlantic stock. This latter now appears to be on the road to complete submergence, owing to its inability to adapt itself as a whole to the increasingly diverse oceanographical conditions.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

ATMOSPHERIC ELECTRICITY.—*On certain new atmospheric-electric instruments and methods.* W. F. G. SWANN. Terr. Mag., **19**: 171–185. 1914.

The first instrument described is a modification of the Ebert ion-counter, designed with a view to securing greatly increased sensitiveness. There are two concentric cylinders, as in the Ebert apparatus, but instead of the central one being connected to an electroscope reading up to 200 volts, as in that instrument, it is connected to the fiber of a single-fiber electroscope of the Einthoven type adjusted to a sensitivity of about 20 or 30 divisions per volt. The potential of the fiber is never allowed to depart far from zero potential and the necessary field is obtained by insulating and charging the outer cylinder to about 200 volts. On releasing the fiber from earth it, of course, starts to move, and the rate of movement can be noted. In order to prevent the charge on the outer cylinder affecting the number of ions coming to the apparatus, it is shielded by another cylinder which is earthed. In order to insure that the charge on the upper edge of the shielding cylinder does not rob the air of ions which should go to the central rod, a special attachment is made to the latter which renders this impossible.

The second portion of the paper describes a modification of Elster and Geitel's apparatus for determining the radio-active content of the atmosphere. Instead of the collecting wire being charged to -2000 volts below the potential of the earth, as in Elster and Geitel's method, it is charged to -2000 volts below the potential which the air in its vicinity would have if it were absent. In this way the charge on the wire, which is shown to determine the amount of active deposit collected, is independent of the potential gradient. A more fundamental unit of activity is suggested than that used by Elster and Geitel. It is

based on the initial rate of production of ions in the ionization chamber, corresponding to unit charge on the collecting wire when exposed. The employment of an Einthoven electrometer in a manner analogous to that adopted in the case of the ion-counter described above renders it possible greatly to increase the convenience, rapidity, and accuracy of the measurements.

The third portion of the paper describes a piece of apparatus suitable for obtaining relative values of the potential gradient. Its action is based on recording the change of potential which a metal disc undergoes when, after being earthed and insulated, it is caused to alter its position in the Earth's field. The chief advantage of the method is that high insulation is not necessary, since it is only while the disc is changing its position that leakage is operative. In view of the slow action of the usual forms of collectors, leakage usually becomes a serious consideration in determining the final potential obtained, especially at sea. Another advantage of the present method is that it enables the potential-gradient to be obtained at any instant.

W. F. G. S.

ATMOSPHERIC ELECTRICITY.—*On certain matters relating to the theory of atmospheric electric measurements.* W. F. G. Swann. Terr. Mag., **19**: 205–218. 1914.

The earthed portions of pieces of apparatus exposed to the atmospheric potential gradient have to take a negative charge in order that their potential may remain zero. The effect of the charge in modifying the measurements is discussed for various cases. In the Ebert ion-counter the effect is to decrease the measured ionic density in the case of the negative ions, while in the case of the positive ions the results are unaffected, though the paths of the ions are of course influenced by the charge. It is shown that the effect is expressible very simply in terms of the charge induced by the potential gradient on the *inside* of the opening where the air enters. By measuring this charge it is possible (knowing the rate of the air flow) to estimate the order of magnitude of the effect. The effect is greatest of course when the apparatus is mounted on a tall slender support. It was found by measurement that it might easily amount to 20 per cent of the value of the quantity measured. The analogous effect is discussed for the case of the Gerdien conductivity apparatus, and it is shown that even in the case of the negative ions no error is introduced, provided that the potential of the central conductor is not too high. In fact the

effect of the potential gradient is simply to lower the value of the maximum potential to which it is allowable to charge the central system. In the case of the conductivity of the positive ions, while the ionic paths are influenced, neither the conductivity nor the maximum potential allowable are influenced on the whole.

The effect of making measurements of conductivity on the top of a high tower is discussed in the above light and it is shown that, if suitable precautions are taken, the proper conductivity will be obtained for the air at that altitude, in spite of the influence of the charge on the tower. There is an advantage in making measurements on the air far removed from the ground, since the number of ions present are then uninfluenced by the effects due to the potential gradient referred to in the first abstract. The question of shielding the instruments to protect them from the potential gradient is discussed. It is only in the case of the Ebert apparatus that shielding of this kind is necessary. It is important to ascertain, however, whether the avoidance of charge on the earthed portions of the apparatus by shielding is not counteracted by the effect of the charge on the shield. It is shown that a properly arranged shield is on the whole effective.

W. F. G. S.

ATMOSPHERIC ELECTRICITY.—*The atmospheric-electric observations made on the second cruise of the Carnegie, 1909–1913.* C. W. HEWLETT. Terr. Mag., **19**: 127–170. 1914.

The atmospheric-electric work on board the *Carnegie* has been confined entirely to observations of the specific conductivity, the potential-gradient, and the radioactivity of the atmosphere, the greater part of the observations consisting of the first two quantities named. The observations are divided naturally into three principal groups, according to the observer who made them. From New York to Colombo, E. Kidson conducted the observations; for the route from Colombo to Manila, owing to breakage in the instruments and the impossibility of having the requisite repairs made, there are no observations; from Manila to Tahiti, H. F. Johnston conducted the observations, and from Tahiti to New York, the work was carried on by C. W. Hewlett. For an account of the instruments and methods used, as well as for the detailed results obtained, reference must be made to the original article.

From a summary of the various results thus far obtained at sea, the following deductions in regard to the mean values of the elements may be drawn: The potential-gradient is of the same order of mag-

nitude over the sea as over the land; the radioactivity of the air over ocean-areas far removed from land is small, compared to that found over land; and the ionization over the ocean is at least as large as that found over land.

C. W. H.

ATMOSPHERIC ELECTRICITY.—*Investigation of certain causes responsible for uncertainty in the measurement of atmospheric conductivity by the Gerdien conductivity apparatus.* C. W. HEWLETT. Terr. Mag., **19**: 219–233. 1914.

The object of the writer was to test experimentally the behavior of the apparatus under various conditions. It was shown theoretically by Dr. Swann that the theory of the apparatus does not necessitate a constancy of the velocity over a cross section of the air current, and that, if the potential is below a certain minimum value depending on the total air flow, the correct value of the conductivity is obtained. By covering up half of the space opposite the fan, a considerable irregularity was produced in the air flow. For low charging voltages, however, the conductivity was practically the same as without the obstruction. As the voltage is increased beyond a certain point, the measured conductivity, without the obstruction, becomes less than that with it, but this is due to the fact that the critical voltage is less with the obstruction than without it, owing to the smaller air flow in the former case.

As the measured conductivity was found to depend upon the presence or absence of the funnel, it was thought advisable to investigate the exact effect of the latter. Certain theoretical considerations point to the conclusion that, in the absence of the funnel, the maximum allowable voltage is reduced, owing to the fact that the stream lines of the air which enter the funnel near the edges suffer sharp bends in that vicinity. Experiments were consequently made to determine whether the effect of the funnel was less important for low charging voltages. It was found that for charging voltages of 10, 30, 50, 70, 100, the relation of the conductivity without the funnel to that with the funnel was 0.98, 0.96, 0.98. 0.94, 0.89; hence the theoretical conclusion that the ratio is practically unity for low voltages, and less than unity for higher voltages, is borne out. Experiments have also been made to determine the effect of the charge induced on the earthed portions of the apparatus owing to the existence of the potential gradient. It is found that under certain conditions this effect may be

considerable. The usual theory of the Gerdien apparatus neglects the effect of the charge collected by the rod which supports the central cylinder. Experiments were made to measure directly this charge, and it was found to be far from negligible in comparison with that collected by the central cylinder. In the use of the Gerdien apparatus it is important that the charging potential shall always be sufficiently low. The most sensitive region of the electroscope supplied with the instruments is usually in the neighborhood of 150 to 200 volts. It has been found, however, that the maximum allowable voltage varies considerably from day to day, presumably owing to variations in the specific ionic velocities. Usually a charging potential of 150 volts is far too high.

C. W. H.

TERRESTRIAL MAGNETISM.—*The local magnetic constant and its variations.* L. A. BAUER. Terr. Mag., **19**: 113–125. 1914.

Good progress has been made by various investigators in establishing the relationship between fluctuations of the Earth's magnetism and those of the Sun's activity during the Sun-spot cycle. The magnetic quantity most frequently used for this purpose has been the range of the diurnal variation—generally of the magnetic declination. In connection with a preliminary examination of this relationship, made in 1909, occasion was found to employ various other magnetic quantities. One of these was what is here termed the "local magnetic constant," which, under certain assumptions, is proportional to the magnetic moment of the Earth, or to the intensity of magnetization; it is thus a quantity which lends itself readily to physical interpretation. The result of chief interest obtained from the 1909 investigation was that an increase in solar activity was accompanied, in general, during 1906 to 1909, by a decrease in the local magnetic constant. Since this investigation, Abbot's extensive observations at Mt. Wilson, California, and Bassour, Algiers, showing the fluctuations in the values of the solar constant of radiation for various years, have become available. The question arises whether any changes in the Earth's magnetism follow the same course as that of the solar constant.

As a provisional result, subject to modification when the final computations have been made, it was found that for a change of 10 per cent observed in the solar-constant values, there is apparently a change in the local magnetic-constant of about 0.03 per cent of its value, *i.e.*, about 10×10^{-5} C.G.S., decreased magnetic constant corresponding to increased solar constant. The effect appears to be most pronounced

for the observatories in the Sun-lit portion of the globe, and seems to be reversed for the observatories in the night portion, judging from the place where the corresponding solar observations are made. This is being looked into further.

In the discussion of magnetic disturbances we may have to distinguish between two broad classes:

(1) The *curvilinear*, the more prominent as far as general magnitude is concerned, occurring practically over the whole Earth at the same time, seemingly initiated by such radiations or streams of charged particles which are deflected from a straight path, when they come under the influence of the Earth's magnetic field, as to pass around and behind the Sun-lit portion of the Earth.

(2) The *rectilinear*, occurring practically only over the portions of the Earth reached by the straight-line, or ordinary, radiations from the Sun. L. A. B.

TERRESTRIAL MAGNETISM.—*Regarding improvement of appliances for measurement of the Earth's magnetic elements by magnetic and electric methods.* (Progress Report.) L. A. Bauer, Terr. Mag., **19**: 1–18. 1914.

The instruments for magnetic measurements, employing distinctively magnetic methods, have now reached the requisite stage of perfection for meeting the practical requirements, both on land and at sea. However, the desire is to devise and try out new methods, as, for example, those based on electrodynamic or electric principles, with a two-fold object in view: (1) to obtain, more expeditiously than is possible with the type of magnetometer now in general use, a magnetic measurement within the relative accuracy required for a successful study of the magnetic variations; (2) to obtain, another control, by means of a distinctively different method, on the absolute accuracy of the present magnetic standards. The present report summarizes what has been done thus far with respect to improvement of the appliances and methods for the measurement of the terrestrial-magnetic elements and what is still further to be undertaken.

In all of the Department's types of magnetometers, the magnet house is of wood. Furthermore, every instrument is as nearly as possible an independent or absolute one, *i.e.*, all the various constants can be absolutely determined. It is shown that, as the result of numerous comparisons, it would seem safe to conclude that the H, or horizontal-intensity, standards of Kew, Potsdam, and Washington (Department of Terrestrial Magnetism) give an absolute accuracy within one part

in 10,000, except for some possible error which may be inherent in the magnetometer-method but not yet disclosed.

When the ocean work of the Department was begun in 1905, it was necessary either to design entirely new, or to modify considerably, existing devices. There have resulted thus new magnetic instruments, for use at sea, designed, as well as chiefly constructed, by the Department. With these instrumental devices, an accuracy in ocean magnetic work has been secured which, under favorable conditions and devoting the same time as in land work, does not fall much short of the general accuracy of land field work. L. A. B.

TERRESTRIAL MAGNETISM.—*Results of magnetic observations made by the U. S. Coast and Geodetic Survey in 1913.* R. L. FARIS. U. S. Coast and Geodetic Survey Special Publication No. 20. Pp. 52. 1914.

In 1882 the results of field magnetic observations made by the Coast and Geodetic Survey prior to 1881, together with descriptions of stations, were published as Appendix 9, Report for 1881. In "Magnetic Declination Tables and Isogonic Charts for 1902" declination results were given for all stations occupied up to that time and descriptions were given of stations established subsequent to 1881. From 1903 to 1911 there was published annually an appendix to the Superintendent's report giving the results of the magnetic observations made during the fiscal year (July to June) covered by the report. Special Publication No. 15 contained the results of magnetic observations made between July 1, 1911 and December 31, 1912.

The present publication contains the results of observations made on land and at sea during the calendar year 1913, and in the Philippine Islands in 1912, together with descriptions of the stations occupied. Results are given for 282 stations in 245 localities including a general magnetic survey of the Philippine Islands, a detailed survey of the crater of Kilauea, Hawaii, and an investigation of the area of local disturbance in the vicinity of Wilmington, Delaware. A table is given presenting a comparison of the declination results at 69 repeat stations with the results of earlier observations in the same localities. The results have been corrected to reduce them to the International Standard of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Horizontal Intensity results heretofore published must be diminished by 1 part in 1000 to reduce them to that standard. D. L. HAZARD.

GEOLOGY.—*The transportation of debris by running water.* GROVE KARL GILBERT. Based on experiments made with the assistance of EDW. CHAS. MURPHY. U. S. Geological Survey Professional Paper 86. Pp. 263. 1914.

For original brief statement of results see this JOURNAL, **4**: 154–158. 1914.

GEOLOGY.—*The Montana group of Northwestern Montana.* EUGENE STEBINGER. U. S. Geological Survey Professional Paper 90-G. Pp. 68. 1914.

For original brief statement of results see this JOURNAL, **4**: 383–384. 1914.

GEOLOGY.—*A reconnaissance in the Canyon Range, west-central Utah.* G. F. LOUGHLIN. U. S. Geological Survey Professional Paper 90-F. Pp. 10. 1914.

The formations studied are all of sedimentary origin and include limestone of lower Mississippian (Madison) age, quartzite of probable upper Mississippian age, Eocene conglomerates and sandstones, and the Pleistocene Lake Bonneville beds. The principal structural features are a series of folds, some open and others close, one of the latter being accompanied by a strike fault of probable reverse character. Evidence of "basin range" faulting is also present. The contact between Eocene and Carboniferous strata indicates that the former were deposited on an erosion surface of considerable irregularity.

The folding of the Carboniferous rocks is believed to have taken place in late Jurassic or post-Jurassic time. This was followed by an erosion period, in Cretaceous time, and by deposition of the Eocene strata, which probably once covered the entire area of the present range. The volcanic eruptions took place in late Eocene or post-Eocene time. The volcanic period was followed by profound faulting and uplift of the range. Sevier River maintained its course during the uplift, cutting through the Eocene beds and following a probable pre-Eocene synclinal valley in the quartzite. Pleistocene time was marked by the deposition of the Lake Bonneville beds and subsequent erosion of them along the present course of Sevier River.

The ore deposits of the range, which is included in the Leamington mining district, include small replacement bodies of oxidized and sulphide lead-zinc ore, with low silver values, and also small showings of oxidized copper minerals in quartz veins, which have been only super-

ficially prospected. The deposits resemble in general character several deposits, low in silver, in neighboring mining districts. G. F. L.

GEOLOGY.—*Reconaissance of oil and gas fields in Wayne and McCreary counties, Kentucky.* M. J. MUNN. U. S. Geological Survey Bulletin No. 579. Pp. 105. 1914. (Prepared in co-operation with the Kentucky Geological Survey.)

The strata which outcrop in Wayne County have a maximum thickness ranging between 1200 and 1500 feet. The upper part of the series consists of sandstone, shale, conglomerate, clay, and coal belonging to the Pennsylvania series ("Coal Measures") of the Carboniferous system. These beds are underlain by about 1000 feet of limestone, shale, and thin sandstone, belonging to the Mississippian series ("sub-Carboniferous"). Pennsylvanian rocks are absent over the northern part of the county and along the principal streams, having been removed by erosion. The maximum thickness, probably 400 or 500 feet, of Pennsylvanian rocks is found in the high hills along the southern border of the county. The limestones and the red and green shales of the upper part of the Mississippian series are exposed along the valleys and hillsides of the mountainous region, and the limestones of the middle and lower part form the surface of the rolling plain in the northern and western portions of the county. These older beds consist of 20 to 40 feet of Devonian shale at the top, underlain unconformably by Silurian or Ordovician limestones down to water level. Over 1500 feet of rocks, mostly limestones, which are not exposed at the surface, are known to have been pierced by a few deep wells.

Most of the oil in this district is found in a cherty geode-bearing limestone called by drillers the Beaver Creek "sand." In well records the Beaver Creek "sand" is shown to vary considerably in distance above the top of the Chattanooga ("Black") shale. In many wells it is as much as 60 feet above the Chattanooga shale, but in most places where productive it appears to be only a few feet above that shale, from which it is separated by light-green and blue clay shales. The writer suspects that in many places where the Beaver Creek "sand" is reported by producers to be "high" above the Chattanooga shale, the true Beaver Creek "sand" may be absent, as in the Beaver Creek mill section, and that certain limestones may have been mistaken for it.

The geologic structure of this region is that of a broad, comparatively shallow trough in which occur many minor anticlines and syn-

clines. The axis of this great trough or synclinorium trends generally northeast and southwest. The general dip of the rocks in Wayne County is toward the southeast and amounts to about 20 feet to the mile. There is, however, considerable difference in the degree and direction of dip from place to place, due partly perhaps to unconformities in the rocks of the different series and systems and to unequal deposition of sediments, but mainly to warping in the process of folding, which caused the minor folds and wrinkles that seem to be so intimately associated with the origin of the oil pools.

ALFRED H. BROOKS.

GEOLOGY.—*The Iditarod-Ruby region, Alaska.* H. M. EAKIN. U. S. Geological Survey Bulletin No. 578. Pp. 45. 1914.

The province treated extends from Yukon River at Ruby to Iditarod River and includes the Ruby, Innoko, and Iditarod mining districts. The hard rocks of the Ruby district belong to an older complex of more or less altered sedimentary and volcanic rocks which can be provisionally correlated with the metamorphic Paleozoic and possibly older rocks of the Yukon-Tanana region. The Innoko and Iditarod districts are underlain by a younger series, predominantly of sedimentary and subordinately of volcanic rocks, in part at least of Cretaceous and probably all of Mesozoic age. Intrusive rocks occur in all the districts. They include granitic batholiths, stocks, dikes and sills, that range widely in lithologic character. In most of the region the hard rocks are heavily mantled by alluvial and possibly lacustrine deposits in the lowlands, by residual clays and fragmental deposits on the slopes and lower ridges, and locally near the higher mountain groups by morainic and glacial outwash deposits.

Auriferous deposits occur in both the Paleozoic and Mesozoic areas, and they are probably related genetically to certain of the younger intrusive rocks. This relation is especially clear in the cases of the monzonites of the Iditarod district and the altered rhyolite porphyry dikes of the Innoko district. H. M. E.

GEOLOGY.—*The ore deposits of northeastern Washington.* HOWLAND BANCROFT; *including a section on the Republic mining district.* WALDEMAR LINDGREN and HOWLAND BANCROFT. U. S. Geological Survey Bulletin No. 550. Pp. 215. 1914.

The area investigated in the reconnaissance whose results are here set forth is situated in the extreme northeastern part of the State of

Washington, containing within its boundaries the whole of Stevens and Ferry counties.

The rocks of this region are referred to the Proterozoic, Paleozoic, Mesozoic, and Cenozoic eras. The rocks classified provisionally as pre-Cambrian are the crystalline schists and metamorphosed limestones and quartzites found between Laurier and Orient. The larger part of the region is occupied by an extensive series of more or less dynamometamorphosed argillites, lime shales, limestones, and quartzites. Because of its general similarity to rocks farther west in Washington, which in places are fossiliferous, this series has been referred to the Paleozoic era. In places these rocks were intruded by diabase or it flowed out over their surfaces and was metamorphosed along with the rest of the series, so that it is now represented by greenstone. In part of the district greenstones are prominent. One of the most conspicuous rocks of northeastern Washington is intrusive granite. It is thought that large batholiths intruded the sedimentary series during Mesozoic time, parts of the batholiths having been subsequently exposed by erosion. The presence of monzonite porphyry in most of the mining districts is believed to be due to later eruptions of the granitic magma, and these may have taken place at intervals from late Mesozoic to early Tertiary time. Lava flows of various types fill many of the erosion depressions in the older rocks, and in places form high mountains. Their eruption is thought to have taken place during Tertiary time. Still later flows of basalt are prominent in the extreme southern part of the area investigated, although some were seen in the Republic district. The gold-quartz veins of the Republic (Eureka) district and the First Thought gold deposits, in the Orient district, are of late Tertiary age and are seliniferous.

The period in which the granite, quartz diorite, quartz monzonite porphyry, and monzonite porphyry and the accompanying dikes were intruded was that of the most extensive mineralization. The major part of the ore deposits are believed to be of Mesozoic age, and they owe their origin to the after effects of igneous intrusion. During the Paleozoic period of dynamometamorphism, while the greenstones were being formed, some of the metallic ores may have been concentrated from the basic rocks, so that a few of the ore deposits in the area may be of Paleozoic age. However, intrusive rocks thought to be of Mesozoic age were found in the vicinity of the greenstones, and it is more likely that the deposits associated with the greenstones are due to the Mesozoic intrusions. ALFRED H. BROOKS.

GEOLOGY.—*Mining districts of the Dillon quadrangle, Montana, and adjacent areas.* ALEXANDER N. WINCHELL. U. S. Geological Survey Bulletin No. 574. Pp. 191. 1914.

The Dillon quadrangle lies in southwestern Montana and is in general mountainous, but it contains one large valley, that of Beaverhead and Jefferson rivers, and numerous smaller valleys. Sedimentary rocks ranging in age from Algonkian, possibly Archaean, to Quaternary, are represented in this province. Igneous rocks include quartz monzonite, occurring in a large batholith, together with various other types of intrusives; volcanics also occur.

The geologic structure was determined largely by the intrusion of the great Boulder batholith, which seems to have penetrated by faulting or thrusting, or by assimilation of material, or by updoming important areas in the quadrangle in Tertiary time, or, more probably by a combination of all these processes.

The principal mineral resources of this area and those adjacent include gold, silver, copper, and lead, and smaller quantities of zinc, iron, manganese, tungsten, antimony, arsenic, bismuth, vanadium, tellurium, and sulphur.

The Boulder batholith in a large sense seems to be in whole or in part the source of many of the ore deposits of the Dillon quadrangle. The ore deposits occur chiefly in fissure veins or in irregular bodies produced by contact metamorphism in limestone or dolomite. Some of the ore deposits are in the form of fissure veins. Others belong to the type of ore disseminated in the country rock.

ALFRED H. BROOKS.

GEOLOGY.—*Electric activity in ore deposits.* ROGER C. WELLS. U. S. Geological Survey Bulletin No. 548. Pp. 1–78. 1914.

Many of the chemical reactions that occur in ore deposits involve oxidation and reduction, and with electrolytes the phenomena of oxidation and reduction are closely linked with electric activity. Many ores are also conductors of electricity. It is therefore possible, and necessary to consider, that balanced chemical action may occur in ore deposits at two points somewhat removed from each other. Such activity would produce different mineral associations than would result from a direct admixture of the chemical agents. One of the simplest possible combinations by which electric action could occur would consist in the presence of two different active solutions in contact with a single body of ore, the two active solutions being united by any "in-

different" electrolyte. Pyrite is so inert to many solutions as to function like an "unattackable" electrode, thus making oxidizing and reducing solutions available for producing electric currents in ore deposits. Differences in polarization were detected, however, and measured when different minerals were employed as anodes and cathodes. R. C. W.

GEOLOGY.—*Geology of the phosphate deposits northeast of Georgetown, Idaho.* R. W. RICHARDS and G. R. MANSFIELD, with preface by H. S. GALE. U. S. Geological Survey Bulletin No. 577. Pp. 74. 1914.

The area discussed lies in southeast Idaho and includes many formations ranging in age from lower Carboniferous (Madison limestone) to Quarternary (chiefly alluvium and basalt). It is traversed by the great Bannock Overthrust, the plane of which is warped and partially eroded. The older rocks constituting the upper block are folded into a series of anticlines and synclines with axes trending slightly west of north. Large bodies of phosphate rock occur in the synclines. The younger rocks of the lower block are also underlain by phosphate. Salt deposits occur along the line of the Bannock Overthrust.

R. W. R.

GEOLOGY AND PALEONTOLOGY.—*Cretaceous deposits of the eastern Gulf region, and species of Exogyra from the eastern Gulf region and the Carolinas.* LLOYD WILLIAM STEPHENSON. U. S. Geological Survey Professional Paper No. 81. Pp. 71. 1914.

The paper is a preliminary general account of the character, distribution, and age relations of the Cretaceous deposits of the eastern Gulf region, followed by detailed descriptions of the species of Exogyra from this region and the Carolinas. It is shown that marine Upper Cretaceous deposits composing certain great formations merge along the strike into marine deposits of different character in such a manner that the relative ages of the deposits in different parts of the area can not be determined by stratigraphic sequence alone. Two major faunal zones characterized respectively by *Exogyra ponderosa* Roemer and *Exogyra costata* Say, and two sub-zones characterized respectively by the genus Mortoniceras and the species *Liopistha protexta* Conrad, are recognized; an unnamed zone in the lower part of the Eutaw formation in the Chattahoochee region is also indicated. Within each of these zones and subzones are found many other species of restricted range. Paleontologic means is thus afforded of establishing the age relations of the deposits.

Included in the paper are tables showing the occurrence and geologic range of Upper Cretaceous fossils, a table indicating graphically lithologic variations and age relations of the Cretaceous deposits, and a geologic map on a scale of 1:2,500,000.

The value of the genus Exogyra in correlation rests on the fact of its extended geographic distribution and the restricted stratigraphic range of its principal species, *Exogyra costata* and *Exogyra ponderosa*.

L. W. S.

GEOLOGY.—*Slate in the United States.* T. NELSON DALE and others. U. S. Geological Survey Bulletin No. 586. Pp. 220. 1914.[1]

Slate, in ordinary usage, denotes a rock with more or less perfect cleavage adapting it to various commercial uses, and in which the particles with few exceptions can not be distinguished except in thin section under a microscope. Slates are classified, according to genesis, into (1) sedimentary and (2) igneous; group (1) being by far the most important and subdivided into:

A. Clay slates: Matrix without any or with very faint aggregate polarization.

B. Mica slates: Matrix with marked aggregate polarization.

A further subdivision of each group is based upon mineral character. Igneous slates are divided into (A) ash slates and (B) dike slates.

The slates of group (A) originate in marine deposits of clay and sand. The angular grains of feldspar and quartz in slate imply the nearness of masses of granitic rocks. The alternation of slate beds with quartzite or grit corresponds to the alternation of extremely fine clayey with sandy sediments from such land masses. These sediments consisted largely of quartz, feldspar and mica, with zircon and other silicates, various compounds of iron, lime and magnesia, together with kaolin from the decomposition of the feldspar.

The next stage in the formation of slate is attributed ultimately to the radiation of the earth's internal heat and the consequent corrugation of its outer portion. One effect of this compression was to metamorphose the shale into slate. This included two processes of uncertain priority. Under the combined presence of moisture and the effect of pressure and heat, both the heat generated by the pressure and that which pervaded the strata at the depth at which they were buried,

[1] This is a revised edition of Bulletin 275 of 1906. The coworkers include: W F. Hillebrand (analyses), E. C. Eckel, A. F. Purdue, L. M. Prindle, F. H. Moffit, C. A. Bonine (geology), M. Merriman (tests), Miss A. T. Coons (statistics).

there occurred such a chemical recombination of the silica, alumina, potash, iron and water of the feldspar, kaolin and iron of the shale, as to generate new potash mica in amount sufficient to constitute, in the mica slates, over 33 per cent of the resulting slate. This muscovite was of infinitesimal thinness and other dimensions and mostly of longish, tapering or ribbonlike outline. Most of these scales arranged themselves with their flat sides parallel to, or overlapping, one another but facing the direction from which the pressure came and also with an angle of inclination governed by that pressure. A small but variable proportion, however, of these scales took such a position that their flat sides became parallel to the direction of the pressure thus giving rise to the "grain."

As mica crystallizes in columnar crystals and as the plates or scales due to its molecular structure are transverse to the crystal column, and as a slab of slate consists largely of parallel scales of mica it may be said to correspond, when held horizontally, to such a crystal held vertically. When a mica slate is cut in thin section across the cleavage its optical behavior under polarized light is like that of a mica crystal cut across its crystal cleavage. Yet as not only a considerable number of the mica scales in slate lie across the cleavage, but as some scales of chlorite and crystals of other minerals do also, the texture of a mica slate combines some of the features of a crystal with some of those of a tissue.

This crystalline fabric may inclose in its meshes any sedimentary particles of quartz, zircon, feldspar, kaolin, or other minerals which were not or could not be made over into mica or secondary quartz but whose alignment became more or less parallel to that of the major part of the new mica. During this metamorphism other chemical combinations were formed by the constituents of the shale, resulting in isolated scales or crystals of chlorite, biotite, various carbonates, pyrite, magnetite, graphite, tourmaline, andalusite, etc. These arranged themselves variously—some in the cleavage direction, some in the grain direction. Lenses consisting of one mineral surrounded by one or two others were also formed and concentrically or radiately arranged. The subjects of slip cleavage, shear-zones, cleavage banding, slate discoloration and weathering are considered in some detail.

T. N. D.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE CHEMICAL SOCIETY

The 241st meeting was held at the Bureau of Standards on Thursday, October 8, 1914.

The Secretary read the announcement of the action of the Directors in establishing the Maryland Section, whose territory covers all that part of the previous territory of the Washington Section lying north of a parallel of latitude through Laurel, Md., including the city of Laurel.

REGULAR PROGRAM

Director S. W. STRATTON outlined the work of the Bureau of Standards, discussing the different kinds of work done and the general plan of organization. Dr. W. F. Hillebrand described, more in particular, the chemical work of the Bureau. He gave statistics to show the variety and magnitude of the regular testing work, and then took up individually the various lines of research which have been carried forward during the past years. The meeting then adjourned for an inspection of some of the laboratories.

The 242d meeting was held at the Cosmos Club on Thursday, November 12, 1914.

The meeting was devoted to the election of officers for 1915. The election resulted as follows: *President:* C. L. ALSBERG, of the Bureau of Chemistry; *First Vice-Pres.:* R. B. SOSMAN, of the Geophysical Laboratory; *Second Vice-Pres.:* H. M. LOOMIS, of the Bureau of Chemistry; *Secretary:* E. C. MCKELVY, of the Bureau of Standards; *Treasurer:* F. P. DEWEY, of the Bureau of the Mint; *Councilors:* J. A. LECLERC, Bureau of Chemistry, P. H. WALKER, Bureau of Standards, J. JOHNSTON, Geophysical Laboratory, F. P. DUNNINGTON, University of Virginia; *Executive Committee,* E. W. BOUGHTON, Bureau of Standards, R. C. WELLS, Geological Survey, A. N. FINN, Bureau of Standards, O. F. BLACK, Bureau of Plant Industry.

The 243d Meeting was held at the Cosmos Club on Thursday, December 10, 1914. The amendments proposed at the last meeting, providing for the separation of the Maryland Section, were passed unanimously. The President called attention to the recent death (on December 5) of DR. A. C. PEALE, one of the first members of the Society, and its Secretary for ten years or more. Dr. Bigelow and Dr. Dewey spoke

briefly upon the work of Dr. Peale. Dr. Le Clerc moved that a committee of three who had been personally acquainted with Dr. Peale be appointed to draw up suitable resolutions. Messrs. F. W. Clarke, W. F. Hillebrand, and F. P. Dewey were appointed.

The following papers were read:

F. P. DEWEY, of the Bureau of the Mint: *The recovery of osmiridium in the electrolytic refining of gold.* Practically all bullion refining in the Mint service is now done by the electrolytic process. After suitable selection, gold anodes containing osmiridium are specially treated. By hanging a beaker under the anode the slime is collected, and from it the grains of osmiridium are washed out. Details of the older and newer procedures were given by the speaker.

Discussion: WELLS spoke of the need for more thorough work on the chemical reactions of the platinum metals. FITZGERALD inquired about the form in which the osmiridium separates, and about the percentages of metals found therein. The iridium varies from 43 to 77 per cent of the alloy. SOSMAN compared the platinum content of the Ural deposits with that of some ores discussed by Dewey, and mentioned that the recently advertised discovery of platinum in Westphalia had turned out to be a fraud. FOSTER inquired about the settling of osmiridium from a silver melt, and also about a reported discovery of platinum at the Katahdin Iron Works in Maine. DEWEY stated that no information about this discovery had been published.

E. H. WALTERS, of the Bureau of Soils: *The presence of primary cleavage products of protein in soils.* In an investigation of a water extract and a dilute alkali (2 per cent sodium hydroxide) extract of a sample of Norfolk sandy loam soil from Virginia, substances were obtained which responded to the characteristic reactions of proteoses and peptones. The color reactions obtained and the methods employed in making a partial separation of these bodies showed that a complex mixture of the various proteoses and peptones was present and persisted in the soil for a considerable period. The experiments described show that proteins undergo hydrolytic decomposition in soil in much the same way as in digestion by enzymes, acids, or alkalines in the laboratory. (Author's abstract.)

Discussion: WELLS inquired about the precipitation of barium carbonate by carbon dioxide. WALTERS stated that the barium is held in solution by carbamino compounds.

A. SEIDELL: *The excretion of thymol in the urine.* Thymol has been widely used in the treatment of the hookworm disease. Being a protoplasmic poison, and its absorption being promoted by the presence of fats and oils, its use is somewhat dangerous. In order to find a safer substitute, experiments have been made to determine the manner of action of thymol in eliminating hookworm. Methods for the elimination of thymol in excreta were studied, and it was found that it can be recovered by two steam distillations, one acid and one alkaline, and then determined in the neutral water solution. Using this method, it was found that no thymol is excreted in feces. It does pass out, how-

ever, in the urine, but in combination as glycuronate. It can be separated therefrom by steam distillation from sulfuric acid solution, followed by an alkaline solution containing certain salts which hold back substances which might interfere with the subsequent bromine titration. Experiments on dogs showed that the thymol excretion ends before 15 hours, but only about one half of the original thymol can be found by the analyses. The remainder may escape in part through the lungs; part of the loss may also be due to the first sulfuric acid distillation.

Discussion: LUBS inquired whether the glycuronate could be separated from urine directly and afterwards decomposed. ALSBERG suggested that part of the thymol might be eliminated either in the form of a decomposition product or as some other compound than the glycuronate, and might not afterwards appear as thymol. SEIDELL stated that the glycuronate is a very stable compound, and doubted whether any other compound was formed. ALSBERG also inquired whether the product obtained and titrated might not be a derivative and not thymol itself. SEIDELL replied that all the properties indicated thymol and not a derivative. Studies of the excretion of phenol suggest by analogy that the explanations advanced are correct. MENGE inquired what confirmatory tests had been made on the recovered thymol; SEIDELL stated that no specific chemical tests were made, but that dependence was placed upon its characteristic odor and physical properties.

ROBERT B. SOSMAN, *Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 286th meeting was held in the lecture room of the Cosmos Club, November 11, 1914.

Informal communications:

CLARENCE N. FENNER on *Babingtonite from Passaic County, New Jersey* (See this Journal **4**: 552-558, 1914).

F. C. SCHRADER: *Mountain leather from Rawhide, Nevada.*

T. WAYLAND VAUGHAN: *Tectonic features of certain volcanic islands in the West Indies.*

Regular program:

N. L. BOWEN: *The importance of crystallization in the differentiation of igneous rocks.* Some experiments were described in which the sinking of olivine and pyroxene crystals was obtained in certain artificial silicate melts. The importance of this process as a means of differentiation of igneous rocks was pointed out. The results were discussed especially in connection with the Palisade diabase still of New Jersey. Reasons were given for considering Prof. J. Volney Lewis correct in his explanation of the olivine-diabase ledge and also the general richness in heavier minerals toward the base as due to the sinking of crystals.

WILLIS T. LEE: *Relation of cretaceous formations to the Rocky Mountains.* This paper is a continuation of one presented a year ago under the title, *Use of physiography in the study of Rocky Mountain stratigraphy,*

in which evidence was presented that seemed to prove that the Dakota sandstone originally extended uninterruptedly over the area now occupied by the Rocky Mountains in Colorado and New Mexico. The present paper presents evidence that the marine Upper Cretaceous formations also originally covered this area, and that the Cretaceous sediments of the Rocky Mountain region came mainly from the continental land mass that lay west of the interior sea during Cretaceous time. That this was the course of the sediments is indicated by the prevalence of sandstone, some of which is conglomerate near the shores of this western continent and by the prevalence of marine shale farther east; and also by the thinning eastward toward the present Rocky Mountains, of sandstones such as the Mesaverde in the San Juan Basin and the Ferron sandstone of Utah and western Colorado, and by the corresponding thickening of the marine shales in the same direction.

Comparison of published sections viewed in the light of personal observation in the field indicates that the Cretaceous formations on opposite sides of the mountains and in the intermontane basins are comparable in thickness, character and stratigraphic succession. The thickness of the Pierre shale, however, as reported from various localities, especially east of the mountains, varies by some thousands of feet. This has been interpreted as due to local down-warps of the Cretaceous floor with assumed corresponding up-warps in the present mountainous area. But it is possible that these great differences in thickness may be due in large part to crushing and other rock movements following deposition rather than to original differences.

It seems probable that the interior Cretaceous Basin which includes the present Rocky Mountain areas was a great geosyncline in which, until near the close of the Cretaceous the main movement was downward, with minor warpings. It also seems probable that there was no effective barrier in the relatively small area now occupied by the mountains to prevent the uniform spread of sediments derived from the continental mass west of the Cretaceous sea. If this hypothesis endures the test of future investigation it should lead to a readjustment of certain correlations that now seem discordant and should indicate definitely that the Cretaceous-Tertiary unconformity represents a clearly defined period of erosion, for the Cretaceous sedimentary rocks must have been removed before the pre-Cretaceous rocks could supply the pebbles found in the basal conglomerates of the Tertiary.

E. W. SHAW: *A study of the Lafayette at and near the type locality.* Although the surface of Lafayette County, Miss., and much adjoining territory is immediately underlain by a thin wash-creep-residuum mantle made up principally of material derived from underlying strata but containing certain elements not found in them, it is concluded from recent studies that no formation such as the Lafayette is conceived and described to be is present in the county from which it was named. On the other hand, such a formation is present in the county just west of Lafayette and in other places in the Coastal Plain, and it therefore appears probable that the concept Lafayette, with certain modifications, will be retained.

At the 287th meeting, November 25, 1914, informal communications were presented by W. T. SCHALLER on:

1. *So-called vanadic ocher.*

2. *The minerals of northern New Jersey which are now represented by casts.*

Regular program:

EDGAR T. WHERRY: *A peculiar oolite from Bethlehem, Pa.* The grains in an oolite limestone show a division, parallel to the bedding, into a light and a dark portion, the latter being the lower. Chemical analysis showed the grains to be higher in dolomite, quartz, kaolin, limonite, and carbon, and lower in calcite and siderite, than the matrix. Microscopic study shows the nuclei to be imbedded in the dark material, which is heaped up around them. It is concluded that the original grains consisted of concentric layers of aragonite, containing more or less carbon, and that, after solidification of the sediment, circulating waters dissolved away the former, the carbon and the nuclei falling to the bottom of the cavities. These were later filled up again by secondary dolomite, the coarse crystallization of which is evident in the sections. The carbon precipitated pyrite from iron sulphate-bearing waters, and, finally, this was changed to limonite by weathering.

J. S. DILLER: *The recent eruptions of Lassen Peak.* Although eruptions have occurred at Mt. Baker and St. Helens as late as 1842 and 1843 the great volcanoes of the Cascade Range are generally regarded as extinct. Lassen Peak, the southern terminus of the Cascade Range, has long been noted for its fumaroles and solfataras, but until recently there has been no explosive action. On May 30, 1914, a series of explosive eruptions began, and up to the middle of November of the same year more than 60 eruptions had occurred.

Some of the various forms of ejected dust-laden vapors, rise more than 10,000 feet above the mountain summit, and the progress of the development of the new crater, from its starting point within the old crater of Lassen Peak up to the western side, where it has broken through the old rim, was illustrated by lantern slides.

Fine dust was scattered over the country in various directions for nearly a dozen miles, and close to the crater the large rock fragments ejected form a stratified rim 25 feet or more in thickness about the new crater. So far as known none of the material was molten at the time of its ejection. The ejected vapors which were almost wholly steam, were slightly acid, with sulphurous odors. W. C. WHEELER treated the ejected dust with water and found both sulphur and chlorine in the resulting acid solution, showing that the ejected vapors were similar to those of the solfataras in the region.

There was once vigorous solfataric action in the old crater, but it had entirely ceased. Its rejuvenation and extension is a matter of special interest. Flashes of light and flying luminous fragments have been reported on good authority, and as the crater gets larger and deeper hotter material is ejected.

That there has been an influx of heat along the throat of the old volcano is highly probable, but the limit is not yet evident.

H. S. WASHINGTON: *The condition of the southern Italian volcanoes.* The speaker gave an account of the conditions of volcanic activity at Vesuvius, Etna, Vulcano and Stromboli as observed by Dr. A. L. Day and himself during the summer of 1914. The talk was illustrated by lantern slides.

Vesuvius was in a fairly active, solfataric condition, with numerous fumaroles. A descent into the crater permitted observation of the mouth formed in May, 1910, in the southwestern part of the crater floor. Two separate columns of brown and white smoke were issuing continuously from an orifice near the bottom of this. No liquid lava was seen, but there was recent pumiceous scoria, which analysis shows to be like the recent Vesuvian lavas. The crater was filled with acid vapors, chiefly SO_3, SO_2 and HCl.

Etna was in a state of mixed solfataric and strombolian activity, though not violent. There was a constant emission of acid smoke, and occasional outbursts from one or more of the five mouths seen at the bottom of the crater, which sent up tall columns of dark smoke to a considerable height. There was no emission of lava, but a constant, though slight, fall of fine ash. The "*bocca*" of 1911 on the northeast flank of the cone had increased in size and was fairly active, emitting much smoke and some ash, but no lava.

At Vulcano the solfataric condition since the eruption of 1888–9 still persists—fumaroles of two distinct types being abundant both within the crater and in the outer slopes of the cone. Many samples of gas were collected, as well as specimens of the very abundant salts covering the upper parts of the cone. These are mostly sulphates of potash and alumina, with some boric acid, for the most part quite free from chlorides.

At Stromboli five distinct small vents in the crater floor were emitting smoke and lapilli, though the mode of activity of each was different. The volcano seemed to be in a state of moderate and normal activity.

At the 288th meeting, December 9, 1914, the presidential address was delivered by the retiring president:

ARTHUR KEITH: *Main features of Appalachian structure* (illustrated). The address will be published on a later date.

At the twenty-second business meeting, which followed the address, the following officers were elected for the ensuing year:

President, T. WAYLAND VAUGHAN; *Vice-Presidents*, ARTHUR C. SPENCER, W. C. MENDENHALL; *Secretaries*, CLARENCE N. FENNER, C. H. WEGEMANN; *Treasurer*, C. A. LESHER; *Members-at-large-of-the-Council*, R. S. BASSLER, G. F. LOUGHLIN, G. C. MARTIN, EUGENE STEBINGER, J. B. UMPLEBY.

FRANK L. HESS, *Secretary.*